- **Internal Structure of Earth and Plate Tectonics**
- **Chapter 2**

The Internal Structure of Earth

- **The Earth is a complex dynamic planet**
- **The Earth has a rigid outer shell, a solid center, and a thick layer of liquid that moves around as a result of dynamic internal processes**
- **The internal process are responsible for the effecting the surface of the earth**

To analyze topography answer these questions

- **What?** The form of the feature or features
- **Where?** The distribution and pattern of the landform assemblage
- **Why?** An explanation of origin and development
- **So What?** The significance of the topography in relationship to other elements of the environment and to human life and activities

The Earth is Layered and Dynamic

- **Four Regions**
  - **The Crust**
  - **The Mantle**
  - **The Outer Core**
  - **The Inner Core**

- **The Inner Core**
  - **Solid and very dense mass having a radius of 808 miles**
  - Both the inner and outer core are made of **iron/nickel or iron/silicate.**
  - Makes up **15% of the Earth's volume and 32% of its mass**
  - The Earth's **magnetic field is generated primarily in the outer core**
  - **Magnetic field changes over time from North Pole to South Pole**
- **The Outer Core**
  - Molten and extending to a **depth of about 1243 miles**
  - **These is where the convection happens**
  - **Above the Inner Core is the Mantle (1864 miles) is a change in mineral composition, called**
  - **The Crust sits on the Mantle where convection takes place moving the plates**

- **Between the Mantle and the crust is the Mohorovicic discontinuity (or Moho)**

- **The outermost hard hell, consists of a broad mixture of rock types**
- **This is called the Lithosphere (from the Greek word for rock)**
  - **Average thickness averages 3 miles, between continental and ocean crusts**
  - **The continents' crust averages more than 5 times that of the oceans crust**

How Do We Know About the Internal Structure of Earth

- **What we have learned about Earth from Earthquakes**
  - Though the study of **Seismology,** we have learned about the structure of the Earth.
  - **Seismology is the study of earthquakes** and the passage if **seismic waves through the earth**
  - These waves are called **P waves and S waves**
    - These waves travel through the earth at different rates
    - It is been through the **study of the travel of these waves that Seismologists have been able to describe the center of the earth.**
  - These studies have been able to determine
    - Where **magma is generated in the asthenosphere**
    - The **existence of slabs of lithosphere that have apparently sunk deep in the mantle**
    - The **extreme variability of lithospheric thickness, reflecting its age and history**

Internal Geomorphic Processes

- **Crustal rearrangement (plate tectonics)**
  - **Folding**
  - **Faulting**
  - **Uplifting**
  - **Earthquakes**
  - **Volcanism**
  - **Extrusive**
  - **Intrusive**

- **External Geomorphic Processes**
  - **Atmosphere and Servere Weathering**
  - **Tsunamis**
  - **Flooding**
  - **Mass Wasting**
  - **Subsidence and Soils**
  - **Atmosphere and Severe Weather**
  - **Hurricanes and Extratropical Cyclones**
  - **Coastal Hazards**
  - **Climate and Climate Change**
  - **Wildfires**

- **Study of these processes Uniformitarianism**

Geologic Time

- **Earth is about 4.6 billion years old**
- **Age of the dinosaurs 160 million years ago**
- **Rocky Mountains uplifted 65 million years ago**

Plate Tectonics

- **The term *tectonics* refers to the large-scale geologic processes the deform the Earth's lithosphere.**
- **Movement of the lithospheric plates**
- **What is Plate Tectonics???**
- **Processes associated with creation, movement, and destruction of the *lithospheric plates* collectively is called plate tectonics**

Plate Tectonics

- **Locations of earthquakes and Volcanoes Define Plate Boundaries**
- Plates may include both a continent and part of an ocean basin or an ocean region alone.
- Some plates are very large, some are very small, are relative to their location.
- Most earthquakes and volcanoes are associated with the interactions of the plate boundaries, mostly defining where they are
- Over the geologic time, plates are formed and destroyed, cycling materials from the interior of the Earth to the surface and back again

- **This is the tectonic cycle**

Plate Tectonics

- **Seafloor Spreading is the Mechanism for Plate Tectonics**
- As plates move over the asthenosphere, they carry the continents embedded within them.
- This idea was first suggested by a German scientist Alfred Wegener in 1915.
- He suggested the theory of ***Continental Drift,*** based on the congruity of the shapes of the continents across the Atlantic Ocean
- He also looked at shapes of both South America and Africa and theorized that the shapes of the two continents fit as if they once were one.
- In the late 1960's this theory was finally accepted when **seafloor spreading** was discovered

Seafloor Spreading is the Mechanism for Plate Tectonics

- **Mid-oceanic Ridges or Spreading Centers** are continuously adding to the edges of the lithosphere
- The other edges of the lithospheric edges are being destroyed at **Subduction Zones** around the Earth
- Continents do not move ***through*** oceanic crust; they are carried along with it with the movement of the plates
- Because of the creation of lithosphere at the Ridges is **balanced** by the consumption of the lithosphere at Subduction Zones
- **The Earth remains constant, neither growing nor shrinking**

Types of Plate Boundaries

- **There are three types of Plate Boundaries**
- **Divergent Boundaries**
    - Where neighboring plates are pulling apart
    - New Lithosphere is released here expanding the ocean floor
    - These are ocean ridges or continental riffs
    - Examples are the Atlantic Ocean Ridge or the Red Sea Riff

Continental and Ocean Floor Rocks

- **Continental crust consists mostly of granite**
- **Less dense**

- **Ocean crust consists mostly of basalt**
- **More dense**
- **Ocean crust is <u>subducted under the continental crust</u>**

Types of Plate Boundaries

- **<u>Convergent Boundaries</u>**
- These are where **<u>plates merge together</u>**
- There are **<u>three basic convergent boundaries</u>**

    - **<u>Ocean-Continental Boundaries</u>** – Ocean plate subduct under the Continental Crust
        - Creates –**trenches, volcanoes** – Chilean Mountains and Trench
    - **<u>Ocean-Ocean Boundaries</u>** – Older Ocean plate subduct under the newer Ocean plate
        - Creates – **volcanic islands, submarine trenches-** Japan and Mariana Trench
    - **<u>Continental-Continental Boundaries</u>** – no subduction happens, uplift occurs
        - Creates- **mountain ranges**- Himalayan Mountains

Transform Boundaries

- **Or a <u>Transform Fault</u>**
- **Where the <u>edges of two plates slide past each other</u>**
- **Contains a <u>series of riffs (spreading) along the fault</u>**
    - **Best known- San Andreas Fault in California**
    - **Causes many earthquakes**
    - **San Francisco on its way to the Gulf of Alaska**

Isostasy

<u>The crust is floating on the denser, deformable mantle below</u>

- Questions:
    - **How deep is the sinking of the crust?**
    - **What determines the areal extent of an isostatic adjustment?**
    - **What is the immediacy of the isostatic response?**

Rates of Plate Motion

- **Plate Motion is a Fast Geologic Process (comparatively)**
- **Plates move a few centimeters per year (about as fast as your fingernails grow)**
- **This can cause some features, streams or rocks to be displaced over time where the feature crosses the fault**

Detailed Look at Seafloor Spreading

- **By the 1950's the theory of Continental Drift accepted**
  - Supported by depth soundings
  - Found seamounts/ridges or trenches
- **Seafloor spreading**
  - **1960's new theory- by Harry Hess and Robert Dietz**
  - **Mechanism for continental drift, mid ocean ridges form from rising mantle creating ridges, spreading the ocean floor**
  - **Verified by the Paleomagnetism—reversal of pole magnetism**

Sea Floor Spreading

- The **Validity of Seafloor Spreading from three sources**:
  - Identification and mapping of the oceanic ridges
  - Dating of volcanic rocks on the floor of the ocean
  - Understanding and mapping the paleomagnetic history of the ocean basins
- **Paleomagnetism**
  - Study of Paleomagnetism history helps to understand sea floor spreading and plate tectonics
  - Because of the convection processes within the earth, the Earth has experienced periodic magnetic reversals.
  - This produces magnetic "stripes" in the iron bearing minerals found on the earth's floor
- **New crust is formed and returned to the mantle every 200 million years**

Hot Spots

- Spots of volcanic activity caused by a thin Earth's crust allowing the magma to move to the surface
- These are called **Hot Spots or Mantle Plumes**
- Hawaii and Yellowstone are known Hot Spots

- As the plate moves across the Hot Spot, a **trail is left, such as the Hawaiian Island archipelago**
- These islands are called *seamounts*
- **Hot Spots help to explain volcanic activity in the middle of plates and help to distinguish the direction of the plate's movement**.

Pangaea and Present Continents

- **Summary of the time line**
  - **450 million years** – **5 continents**- merged together to form **Pangaea**
  - **Next 200 million years; one continent**
  - **200 million years** – **Pangaea starts to break up– Laurasia/Gondwanaland**- then to even smaller pieces
  - **135 million years** -- North and South Atlantic Oceans begin to open, separating South America and Africa, Mediterranean Sea began to close as Africa began to rotate northward toward Asia
  - **65 million years --**North and South Atlantic Oceans joined; South America was new Continent and moving westward, Andes growing, as South America overrides the Pacific Plate. Rockies were rising but not the Sierras

Assembly & Breakup of Pangaea

- **"Today"** South America connected to North America
  - North America separated from Europe
  - Europe, Australia has split from Antarctica
  - India collided with Eurasia-thrusting up the Himalayas
  - All continents are still in motion except for Antarctica
  - Africa is splitting along Great Rift Valley rotating counterclockwise

Future of the continents

- **50 million years from now**
  - Australia will straddle the equator is huge tropical island
  - Africa may pinch the Mediterranean shut
  - East Africa becomes large island like Madagascar
  - The Atlantic will widen while the Pacific will shrink
  - Southern California, now a chilly island will pass San Francisco heading for its ultimate destination in the Aleutian Trench of the Gulf of Alaska

Understanding Plate Tectonics Solves Long-Standing Geologic Problems

- Understanding Plate Tectonics helped to clear up two geological problems:
  - How did fossils of the same animals and plants end up in both South America and Africa
  - Evidence of ancient glaciation on several continents with inferred directions of ice flow were the same as if there was only one continent

How Plate Tectonics Works: Putting it Together

- **Driving Mechanisms that move the plates**
  - **This could be call a "push me pull me" method**
  - The mid ocean ridge pushes new magma up creating new ocean floor, moving the old crust outward
  - The old crust moves outward from the mid-ocean ridge
  - As this happens this crust pushes the lighter continental plates over the asthenosphere
  - The continental plate move until it hits another plate.
  - Depending on the plate, there will be a subduction or a collision, with either volcanoes or trenches built or huge mountain ranges
  - Convection in the mantle and asthenosphere guarantee this process will continue

Plate Tectonics and Hazards

- **Plate Tectonics Affect Us All**
  - The ***Linkages*** of plate tectonics to hazards is obvious
  - Where plate boundaries are located volcanoes and earthquakes are mapped
  - Other conclusions are:
    - Divergent boundaries can be associated with volcanoes if land is associated,
      - Example: Iceland
    - Transform boundaries – earthquake hazards are intensified, and where mountains are found landslides and flooding may be experienced
    - Convergence Boundaries cause many hazards
      - Mountainous areas have landslides and flooding
      - Volcanoes and earthquakes can be expected
- **Plate Tectonics are associated with the natural hazards found around the world**
- **Man only makes the hazards worse**